

CLAIMS

1. A system comprising:

an extruder designed to convey a first stream of a fluid, polymeric material in a downstream direction and having a blowing agent port constructed and arranged to inject a blowing agent into the stream, the extruder adapted to admix the stream with the blowing agent to form a single-phase solution of polymeric material and blowing agent;

a nucleator constructed and arranged to divide the single-phase solution of polymeric material into separate portions and to continuously nucleate each of the separate portions at a rate sufficient to form a microcellular polymeric material.

2. A method comprising:

establishing a stream of polymeric material flowing at a rate of at least about 5 lbs per hour within a polymer processing space between a rotating screw and an extruder barrel;

introducing, into the stream of polymeric material, a blowing agent through a plurality of orifices of the extruder barrel while passing the orifices with a flight of the rotating screw; and

admixing the polymeric material and the blowing agent to form a single-phase solution of polymeric material and blowing agent.

3. A system comprising:

an extruder having a screw constructed and arranged to rotate within a barrel to establish a stream of fluid, polymeric material having a flow rate of at least about 5 lbs per hour,

the extruder including a plurality of orifices connected to a blowing agent source and constructed and arranged to introduce the blowing agent into the stream of fluid, polymeric material while being passed by a flight of the rotating screw,

the extruder designed to admix the polymeric material and the blowing agent to form a single-phase solution of polymeric material and blowing agent.

4. A method comprising:

providing an extruder having an inlet at an inlet end thereof designed to receive a precursor of foamed material, an outlet at an outlet end thereof designed to release foamed material from the extruder, an enclosed passageway connecting the inlet with the outlet

constructed and arranged to advance a fluid polymeric stream within the passageway in a downstream direction from the inlet end toward the outlet end, and a nucleation region at which a single-phase solution of fluid polymeric material and blowing agent flowing therethrough is nucleated;

5 establishing a stream of fluid polymeric material flowing in the extruder in the downstream direction;

 introducing a fluid that is a gas under ambient conditions into the stream at an injection location of the extruder; and

 maintaining the stream, downstream of the injection location and upstream of the
10 nucleation region, within the extruder, under pressure varying by no more than about 1500 psi.

222 5. A system comprising:

15 an extruder having an inlet at an inlet end thereof designed to receive a precursor of foamed material, an outlet at an outlet end thereof designed to release foamed material from the extruder, and an enclosed passageway connecting the inlet with the outlet constructed and arranged to advance a fluid polymeric stream within the passageway in a downstream direction from the inlet end toward the outlet end, and a nucleation region at which a single-phase solution of fluid polymeric material and blowing agent flowing therethrough is
20 nucleated;

 the extruder including a blowing agent port constructed and arranged to inject blowing agent upstream of the nucleation region, the extruder designed to maintain the fluid polymeric stream, downstream of the injection location and upstream of the nucleation region, within the extruder, under pressure varying by no more than about 1500 psi.

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6. A method comprising:

 establishing a stream of a fluid, single-phase solution of a precursor of foamed polymeric material and a blowing agent; and

 continuously nucleating the solution by continuously decreasing the pressure within
30 successive, continuous portions of the flowing, single-phase stream at a rate which increases; and

 forming a microcellular polymeric material.

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5 7. A polymer extrusion apparatus including a polymer nucleator having a polymer receiving end constructed and arranged to receive a fluid, non-nucleated, single-phase solution of a polymeric material and a blowing agent, a nucleated fluid releasing end, and a fluid pathway connecting the polymer receiving end to the releasing end that decreases in cross-sectional dimension in a downstream direction, the apparatus constructed and arranged to feed a fluid, non-nucleated, single-phase solution of a polymeric material and a blowing agent to the nucleator receiving end and to extrude, continuously, microcellular polymeric material in the shape of a continuous extrudate.

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10 8. A polymer forming die including an annular inlet at an upstream end thereof for receiving a single-phase, homogeneous solution of polymeric fluid and blowing agent that is a gas under ambient conditions, an annular outlet at a downstream end thereof for releasing foamed polymeric material, and a fluid pathway connecting the inlet with the outlet, the fluid pathway including a first, upstream section defining a nucleating pathway and a second, downstream section connecting the nucleating pathway with the outlet, the downstream section defining an annular gap of essentially constant width and increasing radius in a downstream direction.

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20 9. A method comprising:
nucleating a single-phase solution of polymeric material and blowing agent, and shaping and releasing shaped microcellular polymeric material, around a wire, to ambient conditions essentially immediately after nucleation, the microcellular polymeric material having cells that are free of a non-atmospheric gas.
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See Fig 14

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25 10. A system for producing microcellular polymeric material, comprising:
an extruder having an inlet at an inlet end thereof designed to receive a precursor of microcellular polymeric material, an outlet at an outlet end thereof designed to release microcellular polymeric material from the extruder, and an enclosed passageway connecting the inlet with the outlet constructed and arranged to receive a blowing agent and to contain a homogeneous, single-phase solution of the blowing agent with the precursor in a fluid state at an elevated pressure within the passageway and to advance the solution as a fluid stream within the passageway in a downstream direction from the inlet end toward the outlet end, the enclosed passageway including a nucleating pathway in which a single-phase solution of

blowing agent and microcellular polymeric material precursor passed therethrough can be nucleated, the nucleated material being released directly to ambient conditions.

wherein the extruder is adapted to receive wire and to position the wire in communication with the passageway.

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222 11. A method comprising continuously extruding microcellular polymeric material having cells of essentially uniform size of less than about 50 microns average size from a single-phase solution of polymeric material and blowing agent contained in extrusion apparatus including a nucleating pathway, the blowing agent present in the solution in an amount less
10 than about 80 percent saturation concentration as determined at the lowest pressure in the system after the point of blowing agent injection prior to the nucleating pathway.

222 12. A method comprising:

15 providing a single-phase solution of polymeric material and blowing agent; and continuously extruding said single-phase solution through an orifice constructed and arranged to provide a polymeric material precursor having cells of essentially uniform size of less than about 50 microns average size and having an average cross-sectional dimension of less than 0.5 mm.

20 13. An article obtained by continuously introducing a blowing agent that is an atmospheric gas under ambient conditions into a polymeric material comprising a polymer selected from the group consisting of crystalline and semi-crystalline polymeric material and causing the material to foam to form a microcellular polymeric material in the shape of a continuous extrusion.

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